APPARATUS AND METHOD FOR HARD HANDOFF

OF DATA PACKET TRANSMISSIONS

FIELD OF THE INVENTION

This invention relates generally to allocating

5 network resources to a mobile terminal and, in particular, to

apparatus and methods used for allocating network resources

to a mobile terminal during a packet hard handoff.

BACKGROUND OF THE INVENTION

With the deployment of third generation cellular

10 systems, operators will be able to provide an extensive

number of data services to cellular subscribers. With these

new data services, each subscriber will be competing for both

signalling channels along with fundamental and supplemental

traffic channels (hereinafter referred to together as traffic

15 channels) for bulk data transfers based on user profile

privileges. This increase in demand for bandwidth will

result in a decrease in available network resources and

potentially an increase in the occurrences in which

insufficient bandwidth is available for all connections

20 within a particular sector and/or cell.

When a mobile terminal travels from a first

coverage area to another coverage area, a competition for

network resources may occur. The nature of the CDMA

frequency reuse assumes an equal distribution of mobile

25 terminals throughout the service area. However, in reality,

unequal call loading frequently occurs, thus possibly causing

a mobile terminal to have little choice but to drop its

connection. If the mobile terminal is operating within a

packet data session at the time its wireless connection is

30 dropped, the packet data session will also be disconnected.

The establishment of data packet sessions require considerable signalling and the time required to re-establish a packet data session is inconvenient for customers. Thus, any technique to avoid the need to re-establish packet data sessions is important.

As currently designed, the handoff algorithms defined within standards and implemented within products currently utilized for voice communications are continuing to be used for the transmission of data packets. Unfortunately, data packet traffic and voice communications have different operating parameters that make the use of a common handoff technique potentially inefficient.

Hence, a new hard handoff technique is needed that takes advantage of the unique characteristics of packet data transmissions such that the need to re-establish a data packet session in cases of insufficient network resources (eg. overloaded cells/sectors) is reduced.

SUMMARY OF THE INVENTION

The present invention is directed to apparatus and method for allocating network resources associated with radio sectors within a wireless network to a mobile terminal. In embodiments of the present invention, by inquiring with a centralized Radio Resource Manager (RRM) within the wireless network, a handoff manager determines if a particular sector in which a mobile terminal is being handed off to has sufficient network resources to support the mobile terminal. If it does not have sufficient network resources, the handoff manager instructs the mobile terminal to switch into a dormant mode. By doing this, the handoff manager can delay the disconnection of the packet data session until there is sufficient network resources or until an internal packet data

protocol error occurs due to a request timing out. In the case that sufficient resources become available, the handoff manager instructs the mobile terminal to return to connected mode while, in the case that an internal packet data protocol
5   error occurs, the handoff manager can proceed to disconnect the old connection and the packet data session. One advantage of the present invention is the reduced need to re-establish a data packet session in cases that there is a temporary lack of sufficient network resources during a hard
10   handoff procedure.

The present invention, according to a first broad aspect, is a computing apparatus arranged to operate within a wireless network including at least one radio sector in which mobile terminals can communicate. The computing apparatus
15   includes network resource allocation logic that operates to request allocation of a network resource associated with the radio sector for the mobile terminal and to determine if the allocation of the network resource associated with the radio sector is successful. If the allocation fails, the network
20   resource allocation logic further operates to request the mobile terminal be placed within a dormant mode.

In some embodiments of the present invention, the network resource allocation logic further operates to continue to request allocation of the network resource
25   associated with the radio sector for the mobile terminal after the allocation has previously failed. Further, the network allocation logic operates to determine if the allocation of the network resource associated with the radio sector is successful after the allocation has previously
30   failed and, if the allocation is successful, to request the mobile terminal be placed within a connected mode.

According to a second broad aspect, the present invention is a computing apparatus arranged to control allocation of network resources for a mobile terminal within a radio sector. In this aspect, the computing apparatus

5   includes means for attempting allocation of a network resource associated with the radio sector for the mobile terminal, means for determining if the allocation of the network resource associated with the radio sector is successful and means for requesting the mobile terminal be

10 placed within a dormant mode if the allocation of the network resource associated with the radio sector fails.

The present invention, according to a third broad aspect, is a method for allocating network resources associated with a radio sector to a mobile terminal. This

15 method includes the steps of attempting to allocate at least one network resource associated with the radio sector to the mobile terminal and, if the allocation of the at least one network resource fails, requesting the mobile terminal be placed within a dormant mode.

20 The present invention, according to a fourth broad aspect, is a method for performing a hard handoff of a mobile terminal from a first radio sector to a second radio sector. This method includes determining if network resources of the second radio sector are sufficient for the mobile terminal.

25 Further, if the network resources of the second radio sector are not sufficient for the mobile terminal, the method includes instructing the mobile terminal to be placed within a dormant mode until sufficient network resources for the mobile terminal are available.

30 According to a fifth broad aspect, the present invention is a wireless communication network including a

Radio Access Port (RAP) that operates to communicate with mobile terminals within at least one radio sector and a computing apparatus. The computing apparatus, according to this aspect, operates to attempt to allocate a resource

5   associated with the RAP to a mobile terminal and, if the attempt to allocate resources associated with the RAP to the mobile terminal fails, to request that the mobile terminal be placed within a dormant mode.

The present invention, according to yet a further

10   aspect, is a wireless communication network including first and second Radio Access Ports (RAPs) that operate to communicate with mobile terminals within first and second radio sectors respectively and a computing apparatus. The computing apparatus, in this aspect, operates to detect if a

15   mobile terminal communicating with the first RAP requires a hard handoff from the first radio sector to the second radio sector. Further, the computing apparatus operates to attempt to allocate a resource associated with the second RAP to the mobile terminal if a hard handoff is required. Finally, the

20   computing apparatus yet further operates to request the mobile terminal be placed into a dormant mode if the attempt to allocate the resource fails.

Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art

25   upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiment of the present invention

30   is described with reference to the following figures, in which:

FIGURE 1 is a block diagram illustrating two multi-sector, multi-carrier Radio Access Ports (RAPs) with overlapping coverage areas;

FIGURE 2 is a block diagram illustrating a wireless network model in which the present invention could be implemented;

FIGURE 3 is a signalling diagram illustrating a set of control signalling messages performed during a well-known hard handoff procedure;

FIGURE 4 is a signalling diagram illustrating a subset of the control signalling messages of FIGURE 3 performed during a sample hard handoff according to the present invention; and

FIGURE 5 is a flow chart illustrating the steps performed by the Handoff Manager (HM) of FIGURE 2 in an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Embodiments of the present invention are directed to allocating network resources to mobile terminals and, in particular, to apparatus and methods used for allocating network resources to a mobile terminal during hard handoffs of data packet transmissions. Data packet transmissions have different properties when compared to well-known voice transmissions and as such can be treated in a slightly modified manner. The present invention takes advantage of the fact that data packet transmissions can, within advanced wireless standards, be put into a dormant state in order to reduce the need to tear down a connection when resources are not immediately available.

Within the developing CDMA standard, a Machine Access Control (MAC) is implemented that allows mobile

terminal controlling components, such as a Radio Link Access (RLA) within the wireless network to instruct a mobile terminal to be placed within one of four well-known states, herein below referred to as cdma2000 modes. These cdma2000

5 modes comprise a "connected" mode in which both signalling and traffic channels are active; a "control hold" mode in which only a signalling channel is active; a "dormant" mode in which neither a signalling channel nor a traffic channel is active but a packet data session can be maintained; and a

10 "null" mode in which no channels or sessions are active. In normal situations, the dormant mode is utilized during normal pauses within data requests during a packet data session. Within the present invention, this dormant mode is utilized to aid in hard handoffs as will be described herein below in

15 detail.

Although the embodiments of the present invention as described herein below are specific to the cdma2000 standard, this should not limit the scope of the present invention. It should be understood that the present

20 invention could be applied to any wireless standard that allows a mobile terminal to be put into a state of no communications while maintaining a packet data session.

FIGURE 1 is a block diagram of a wireless network in which two Radio Access Ports (RAP1,RAP2) 20,24 have

25 overlapping coverage areas 22,26 respectively. As depicted, the first coverage area 22 for RAP1 20 has three equal sectors labelled $\alpha_{1,2}$, $\beta_{1,2}$ and $\delta_{1,2}$. Similarly, the second coverage area 26 for RAP2 24 has three equal sectors labelled $\alpha_{1,2}$, $\beta_{1,2}$ and $\delta_{1,2}$. In each of these coverage areas, the two

30 numbers after the sector labels indicate that each sector has two carrier frequencies, frequencies 1 and 2. Further within

FIGURE 1, a Mobile Terminal (MT) 28 is depicted moving from the $\alpha_{1,2}$ sector of the first coverage area 22 to the $\beta_{1,2}$ sector of the second coverage area 26.

In the situation of FIGURE 1, the RAP1 20
5   communicates with mobile terminals within its $\alpha_{1,2}$ sector at one of the carrier frequencies 1 and 2 and the RAP2 24 communicates with mobile terminals within its $\beta_{1,2}$ sector at one of the carrier frequencies 1 and 2. A MT moving from the $\alpha_{1,2}$ sector of the first coverage area 22 to the $\beta_{1,2}$ sector of
10   the second coverage area 26 could be required to change carrier frequencies or may be able to stay within the same carrier frequency depending upon the resource utilization within the RAP2 24 with respect to its $\beta_{1,2}$ sector. If no carrier frequency change is required, the MT can possibly
15   perform a soft handoff between the two sectors. If a carrier frequency change is required during the handoff procedure, the handoff from the RAP1 20 to the RAP2 24 must be a hard handoff since a MT can only communicate on a single carrier frequency at any one time. For the sample description of the
20   present invention below, the MT 28 of FIGURE 1 is assumed to be performing a hard handoff procedure as it moves from the $\alpha_{1,2}$ sector of the first coverage area 22 to the $\beta_{1,2}$ sector of the second coverage area 26.

A well-known hard handoff procedure that takes
25   place within a wireless network for the situation depicted within FIGURE 1 is described herein below with reference to FIGURE 3, followed by a description of a modified hard handoff procedure according to an embodiment of the present invention with reference to FIGURE 4. Prior to these
30   descriptions of hard handoff procedures, a description of a possible wireless network that could have the present

invention implemented is described with reference to FIGURE 2 followed by a description of a possible packet data session initiation procedure within this wireless network.

5   Within FIGURE 2, the MT 28 is depicted moving away from the RAP1 20 towards the RAP2 24. In this figure, both the RAP1 20 and the RAP2 24 are coupled to a RAP control apparatus 30 and more specifically to a Radio Link Access/Radio Resource Manager (RLA/RRM) 32 within the RAP control apparatus 30. Further, the RAP control apparatus 30

10   comprises a Handoff Manager/Packet Session Manager (HM/PSM) 34 coupled to the RLA/RRM 32; a Connection MANager (CMAN) 36 coupled independently to the RLA/RRM 32 and the HM/PSM 34; and a Paging and Access Channel Manager (PAM) 38 coupled to the RLA/RRM 32. Also within the wireless network of FIGURE 2

15   is a Packet Switch Subscriber Manager (PSSM) 42 coupled to both the PAM 38 and the HM/PSM 34; a Circuit Switch Subscriber Manager (CSSM) 44 coupled to both the CMAN 36 and the PSSM 42; a Packet Handler (PH) Pool 46 coupled to the HM/PSM 34; and a PH 48 coupled to the PH Pool 46.

20   The wireless network configuration of FIGURE 2 and the normal operation of its components would be well-known by a person skilled in the art. One such well-known normal operation of its components is the establishment of a packet data session between the MT 28 and a packet-based network

25   (not shown) upon request. This well-known procedure for establishing a wireless packet data session comprises numerous operational steps with considerable control signalling. As described previously, in normal operation, if a lack of sufficient resources occurs during a packet data

30   session, the session is terminated, thus requiring the numerous operational steps to be performed again in order to

re-establish the session when sufficient resources are
available.

        As will be described herein below, one advantage of
the present invention is the reduced need to re-establish a
5   packet data session in the case of a temporary lack of
sufficient resources occurring during a hard handoff. To
emphasize the importance of this advantage of the present
invention, a possible set of operational steps performed in
order to establish a packet data session is now summarized
10 below.

        Firstly within a packet data session initiation
procedure, the MT 28 requests a packet session by sending a
service request message to the PSSM 42 via the RAP1 20,
RLA/RRM 32 and PAM 38; the RAP1 20 encapsulating MT
15 identification and Class Of Service (COS) information within
the Service Request message, the RLA 32 re-assembling the
message from the radio link frames and the PAM inserting
routing area and sector information into the Service Request
message. Next, the PSSM 42 sends a Dedicated Signalling
20 Channel (DSC) allocate request, via the CMCN 44, to the CMAN
36 which results in the required DSC for the MT 28 being
assigned by the CMAN 36.

        Subsequently, the PSSM 42 obtains the profile of
the MT 28 according to its MT identification information and
25 exchanges wireless access authentication information with the
MT 28 via the DSC. If the authentication process is
successful, the PSSM 42 updates the current location of the
MT 28 and performs COS screening, performs service
negotiations with the MT 28 to decide on an agreed COS and
30 defines a routing policy for determining a Wireless Gateway
Node (WGN) (not shown). If the requested service can be

supported, the PSSM 42 then sends a Data Traffic Channel
(DTC) allocate request to the HM/PSM 34 to set-up the DTC
(also known as the bearer path).

At this point, the HM/PSM 34 creates a packet
5   session, determines a PH Pool 46 for delivering the packets
and requests the PH Pool 46 to allocate a PH 48. Further,
the HM/PSM 34 requests the RLA/RRM 32 to allocate and assign
a DTC to the MT 28. This DTC request includes forwarding
identification information, sector information and an
10   encryption parameter for the MT 28 and the address of the PH
48 that has been allocated for the MT 28. The RLA/RRM 28
subsequently stores the encryption parameter and the address
of the PH 48 and responds to the PSM 40 indicating that the
DTC establishment was successful.

15   Next, the HM/PSM 34 sends a DTC allocate response
to the PSSM 42 indicating that the DTC was successfully
established. The PSSM 42 then sends a service response
message, via the PAM 38, RLA/RRM 32 and RAP1 20, to the MT 28
indicating that the requested packet data session has been
20   created. When the RLA/RRM 32 and the MT 28 receive this
service response message, they initialize a Radio Link
Protocol (RLP) on both sides of the radio interface and the
MT 28 obtains its Internet Protocol (IP) address. In this
process, the HM/PSM 34 learns the IP address of the MT 28,
25   correlates the IP address with the MT address of the MT 28
and updates the PH 48 with this IP address. At this point,
the MT 28 would be in the connected mode with a packet data
session established.

It should be recognized that although the procedure
30   above is one possible set of operations performed to
establish a packet data session, there are other possible

procedures to set-up such a session. The above description
is simply a description of one possible wireless packet data
session initiation procedure for a particular wireless
standard that illustrates the complexity of establishing a

5   packet data session within a wireless network.

A well-known hard handoff procedure is now
described with reference to FIGURE 3 followed by a
description of a possible modified hard handoff procedure
according to the present invention with reference to FIGURE

10   4. FIGURE 3 is a signalling diagram illustrating a set of
control signalling messages performed during a well-known
hard handoff procedure while FIGURE 4 is a signalling diagram
illustrating a subset of the control signalling messages of
FIGURE 3 that are modified for a sample implementation of the

15   present invention. For these signalling diagrams, it is
assumed that the packet data session described above has
previously been initiated.

Initially within the well-known hard handoff
procedure of FIGURE 3, the MT 28 detects a new pilot signal

20   sufficient for call processing within the $\beta_{1,2}$ sector of the
RAP2 24 and sends a Pilot Strength Measurement (PSM) message
60 to the RAP1 20. This PSM message 60 is sent in-band
within the established DSC or alternatively, is sent out-of-
band within the established DTC. The PSM message 60 includes

25   identification information for the MT 28; pilot strength
measurements for both the original $\alpha_{1,2}$ sector within the
first coverage area 22 and the new $\beta_{1,2}$ sector within the
second coverage area 26; and the pilot set.

Once the RAP1 20 receives the PSM message 60, it

30   forwards the PSM message 60 to the RLA/RRM 32 where the RLA
re-assembles the message, converts the air interface frames

into a signalling packet and forwards the PSM message 60 to
the HM/PSM 34. The HM/PSM 34 computes pilot sets at step 62
within FIGURE 3 and detects whether a hard handoff is
required at step 64. If the HM/PSM 34 determines that a hard

5   handoff is required at step 64, the HM/PSM 34 sends a DSC
allocate request 66 to the RLA/RRM 32, the DSC allocate
request 66 requesting a DSC to be allocated for the MT 28 in
the new $\beta_{1,2}$ sector. The RLA/RRM 32 then determines whether
there are sufficient resources for the requested DSC and, if

10   there are sufficient resources, the RLA/RRM 32 allocates the
DSC to the MT 28 at step 68. The RLA/RRM 32 subsequently
sends a DSC allocate response 70 to the HM/PSM 34 that
indicates that the requested DSC allocation is complete.

     Next, as depicted in FIGURE 3, the HM/PSM 34 sends

15   a DTC allocate request 72 to the RLA/RRM 32 to request the
allocation of a DTC within the new $\beta_{1,2}$ sector for the MT 28.
Similar to step 68, the RLA/RRM 32 then determines whether
there are sufficient resources for the requested DTC and, if
there are sufficient resources, the RLA/RRM 32 allocates the

20   DTC to the MT 28 at step 74. After the DTC is allocated, the
RRM requests the RAP2 24 to forward data traffic to the MT 28
with a Forward Traffic (FT) request 74 and the RAP2 24
acknowledges with a FT response 78. At this point, the RAP2
24 begins attempting to forward data traffic to the MT 28 at

25   step 80 and the RLA/RRM 32 sends a DTC allocate response 82
to the HM/PSM 34 to indicate that the DTC allocation is
complete.

     As depicted in FIGURE 3, the HM/PSM 34 next sends a
Segmentation and Distribution Unit (SDU) allocate request 84

30   to the RLA/RRM 32, the SDU allocate request 84 indicating
parameters related to the MT 28. The RLA/RRM 32 then

allocates an SDU within the new $\beta_{1,2}$ sector to the MT 28 at step 86 if sufficient resources allow it and sends an SDU allocate response 88 back to the HM/PSM 34 to indicate that the SDU allocation is complete.

5   Once the SDU allocation is done, the HM/PSM 34 sends a connection request 90 to the CMAN 36, the request 90 including parameters indicating the end point resources utilized with the new established DSC and DTC. The CMAN 36 then establishes a new call tree with these parameters for

10   the MT 28 within a connection table at step 92 and sends a connection response 94 to the HM/PSM 34 to indicate that the connection has been recorded.

Finally, the HM/PSM 34 inserts the connection specifics within a local table of the HM at step 96 and sends

15   a HandOff (HO) message 98, via the previous DSC consisting of the RLA/RRM 32 and RAP1 20, to the MT 28 which informs the MT 28 of its new assigned channels and pilot sets. The MT 28 uses this information to update its pilot sets at step 100, begins to listen to the new DSC and DTC at step 102 and sends

20   a HO complete message 104 back, via the previous DSC, to the HM/PSM 34. At this point, the MT 28 starts to send reverse traffic in the new DSC and DTC at step 106 which are received at the RLA/RRM 32 at step 108 while the HM/PSM 34 begins to terminate the previous channels via RAP1 20.

25   To terminate the previous channels, the HM/PSM 34 sends a disconnect request 110 to the CMAN 36 that indicates the resources of the previous SDU, DSC and DTC that should be de-allocated. Subsequently, the CMAN 36 requests the RLA/RRM 32 to de-allocate the SDU by sending an SDU de-allocate

30   request 112 that indicates the SDU of the previous connection, the RLA/RRM 32 de-allocates the SDU of the

previous connection at step 114 and the RLA/RRM 32 sends a
SDU de-allocate response 116 to the CMAN 36. Next, a similar
termination procedure is conducted for the DSC and DTC of the
previous connection. For this, the CMAN 36 sends respective

5   DSC and DTC de-allocate requests 118,124 to the RLA/RRM 32,
the RLA/RRM 32 performs the DSC and DTC de-allocations at
respective steps 120,126 and the RLA/RRM 32 sends respective
DSC and DTC de-allocate responses 122,132 to the CMAN 36 to
indicate that the de-allocation has occurred. Prior to the

10   sending of the DTC de-allocate response, the RLA/RRM 32
further sends a stop FT request 128 to the RAP1 20 at which
point the RAP1 20 stops attempting to forward data traffic to
the MT 28 and sends a stop FT response 130 to the RLA/RRM 32.
        At this point, the CMAN 36 updates, at step 134, a

15   connection table with the details of the new connection for
MT 28, thus indicating that the network resources of the
previous connection are free to be used for other
connections. Finally, the CMAN 36 sends a disconnect
response 136 to the HM/PSM 34 and the HM/PSM 34 removes the

20   old connection from its local table at step 138.
        The procedure described above for a well-known hard
handoff of a MT from a first RAP to a second RAP is specific
to the case in which all resources necessary for the
connection between the MT and the second RAP are available.

25   For instance, for the above described procedure to operate
properly, sufficient bandwidth must exist to establish the
DSC and DTC, among other network resource issues. If any of
the necessary network resources are unavailable, the hard
handoff will fail and the connection between the MT and the

30   wireless network will be torn down along with the associated
packet data session.

Once there are sufficient resources to allow for the connection to be made between the MT and the second RAP, a connection can be reinitiated followed by an initiation of a new packet data session. Problems with this situation

5 include the considerable amount of control signalling that is necessary to establish a new packet data session as well as the customer dissatisfaction that is generated due to the inconvenience that results from initiating a new packet data session.

10 FIGURE 4 is a signalling diagram illustrating a modified subset of the control signalling messages of FIGURE 3 performed during a sample hard handoff according to the present invention. In this subset of control signalling messages, the capability of the MT 28 to be placed into a

15 dormant mode is taken advantage of. As depicted in the sample hard handoff of FIGURE 4, the control signalling and operational steps 60 through 72 operate as previously described with reference to FIGURE 3. The MT 28 sends a PSM message 60 to the HM/PSM 34 via RAP1 20 and RLA/RRM 32; the

20 HM/PSM 34 decides that a hard handoff is necessary at steps 62 and 64; the HM/PSM 34 proceeds to have the RLA/RRM 32 allocate a DSC for the new connection at step 68; and the HM/PSM 34 requests for a DTC for the new connection to be allocated by the RLA/RRM 32 by sending a DTC allocate request

25 72.

Subsequently in this sample hard handoff procedure, the RLA/RRM 32 determines that the allocation of the requested DTC is not possible as depicted at step 200. This determination could occur for a number of reasons including

30 the RAP2 24 having insufficient resources to accommodate the MT 28 within the $\beta_{1,2}$ sector or the RAP2 24 prioritizing other

MTs above the MT 28. Once the determination is made that the allocation of a DTC for the MT 28 is not possible, the RLA/RRM 32 sends a DTC allocate failure message 202 to the HM/PSM 34. At this point in the well-known hard handoff

5   procedure of FIGURE 3, the HM/PSM 34 would send the disconnect request 110 to the CMAN 36 to initiate the disconnecting of the MT 28 from the network and the signalling and control steps 112 through 138 would proceed.

Within the sample implementation of the present

10   invention depicted in FIGURE 4, when the allocation of a DTC for the MT 28 within the new sector is not possible, the HM/PSM 34 sends a dormant mode request 204 to the RLA/RRM 32 which is subsequently forwarded to the MT 28 via the RAP1 20. Once received, this dormant mode request 204 instructs the MT

15   28 and the RAP1 20 to place all signalling and traffic channels between the devices into the dormant state such that neither device utilizes the established channels.

Next, the HM/PSM 34 continues to periodically send DTC allocate requests 206 to the RLA/RRM 32, similar to the

20   DTC allocate request 72. Each time the RLA/RRM 32 receives a DTC allocate request 206, a determination is made whether the requested allocation of a DTC is possible for the MT 28 within the new $\beta_{1,2}$ sector. If the allocation of the DTC continues not to be possible, for such reasons as

25   insufficient network resources to accommodate the DTC, the RLA/RRM 32 continues to send DTC allocate failure messages to the HM/PSM 34. On the other hand, if the RLA/RRM 32 determines that it is possible to allocate a DTC for the MT 28 within the new $\beta_{1,2}$ sector, the RLA/RRM 32 allocates the

30   DTC at step 208, sends a FT request 76 to the RAP2 24 and, once a FT response 78 is received from the RAP2 24, sends a

DTC allocate response 82 to the HM/PSM 34. At this point,
the hard handoff procedure of FIGURE 3 continues at step 84
by sending an SDU allocate request 84 to the RLA/RRM 32, the
RLA/RRM 32 allocating an SDU within the new $\beta_{1,2}$ sector to the

5   MT 28 at step 86 if sufficient resources allow it and the
RLA/RRM 32 sending an SDU allocate response 88 back to the
HM/PSM 34 to indicate that the SDU allocation is complete.
Next, the HM/PSM 34 sends a connection request 90 to the CMAN
36, the CMAN 36 establishes a new call tree with these

10 parameters for the MT 28 within a connection table at step 92
and the CMAN 36 sends a connection response 94 to the HM/PSM
34 to indicate that the connection has been recorded.

At this point, the HM/PSM 34 sends a connected mode
request 210 to the MT 28 via the RLA/RRM 32 and the RAP1 20

15 prior to continuing with the hard handoff procedure of FIGURE
3 at step 90. The connected mode request 210 instructs the
MT 28 and the RAP1 20 to return to the connected mode in
which they can communicate over the previously established
signalling and traffic channels. After the sending of the

20 connected mode request 210 from the HM/PSM 34, the hard
handoff procedure of FIGURE 3 continues at step 96.

The time between the MT 28 receiving the dormant
mode request 204 and receiving the connected mode request 210
is critical to the proper maintenance of the packet data

25 session during a hard handoff in which there is a temporary
lack of sufficient resources within the new sector. This
time lag is critical since well-known protocols utilized
within packet data sessions generally have predetermined wait
times in which devices utilizing the protocol wait can for a

30 response to a data request prior to declaring an error with
the transmission. If the delay between receiving the dormant

mode request 204 and receiving the connected mode request 210
is too large (i.e. too large a time period in which
insufficient resources are available in the new sector), than
the error that results will cause the packet data session to
be terminated at the MT 28 level. The termination of the
packet data session at the MT 328 will result in the need for
initiation of a new packet data session once the MT 28 the
hard handoff has been completed, thus removing the benefit of
the present invention.

It should be recognized that different packet data
session protocols would have different lengths for their wait
times. If the wait time is relatively short, the chances
that a transmission error is detected while the MT 28 is
within the dormant mode is higher while, if the wait time is
relatively long, the chances are lower. In some protocols,
it could be conceivable that the wait time does not exist and
so this problem of transmission errors occurring while the MT
28 is within the dormant mode is not relevant.

Although the signalling diagram of FIGURE 4
illustrates a sample hard handoff procedure in which a
failure occurs when allocating the new DTC, it should be
recognized that the present invention could be expanded such
that a similar procedure of requesting a dormant mode occurs
in cases that any required network resources cannot be
allocated to the new connection. For instance, if
insufficient network resources do not allow a DSC or SDU to
be allocated to the MT 28 within the new sector, a similar
dormant mode request could be sent to the MT 28 and the RAP1
20.

Yet further, although the signalling diagram of
FIGURE 4 illustrates the case in which a connected mode

request is sent from the HM/PSM 34 after the completion of
the SDU allocation, this is not meant to limit the scope of
the present invention. In alternative embodiments, a
connected mode request is sent after receiving the DTC

5   allocate response 82.

FIGURE 5 is a flow chart illustrating the steps
performed by the HM/PSM 34 in an embodiment of the present
invention in which a similar procedure to that illustrated in
the example of FIGURE 4 occurs in the case of any failure to

10 allocate network resources. Initially within the flow chart
of FIGURE 5, the HM/PSM 34 receives a PSM message from a MT
at step 300, computes the pilot for the MT at step 302 and
determines if a hard handoff is required at step 304. If a
hard handoff is not required, the procedure returns to step

15 300 as depicted within FIGURE 5. It is noted that the HM/PSM
34 would also determine whether a soft handoff should occur,
though this is not shown within FIGURE 5 as it is not
directly relevant to the present invention.

If a hard handoff is required at step 304, the

20 HM/PSM 34 next sends a DSC allocate request to the RLA/RRM 32
at step 306 and waits for either a positive response to the
DSC allocate request or a failure message at step 308. If a
failure response is received at step 308, the HM/PSM 34 sends
a dormant mode request to the MT and its RAP via the RLA/RRM

25 32 at step 310 if the MT is not previously within the dormant
mode. Subsequently, the HM/PSM 34 determines if the wait
time for the particular packet data session protocol that is
used has expired at step 312. In alternative embodiments of
the present invention, no determination is made with respect

30 to the expiration of the wait time of the packet data session
protocol. The advantage of having such a wait time

expiration detection is the added ability to avoid further
signalling in cases that the packet data session has already
terminated. If the wait time has not expired at step 312,
the HM/PSM 34 returns to step 306 while, if the wait time has
5   expired, the HM/PSM 34 proceeds to disconnect the current
connection with the MT as will be described below.

      If a positive response is received from the RLA/RRM
at step 308, the HM/PSM 34 proceeds to send a DTC allocate
request to the RLA/RRM 32 at step 314 and monitor at step 316
10   for a positive response or a failure message in response to
the DTC allocate request. If a failure message is received
at step 316, the HM/PSM 34 proceeds to send a dormant mode
request to the MT and its RAP at step 318 if the MT has not
previously been instructed to be in the dormant mode.
15   Further, the HM/PSM 34 determines if the wait time has
expired at step 320 similar to step 312. If the wait time
has not expired, the HM/PSM 34 returns to step 314 while, if
the wait time has expired, the HM/PSM 34 proceeds to
disconnect the current connection with the MT as will be
20   described below.

      If a positive response is received at step 316, the
HM/PSM 34 sends an SDU allocate request to the RLA/RRM 32 at
step 322 and monitors at step 324 for a positive response or
a failure message from the RLA/RRM 32. If a failure message
25   is received at step 324, the HM/PSM 34 sends a dormant mode
request to the MT and its RAP at step 326 if the MT is not
previously within the dormant mode. Next, the HM/PSM 34
determines if the wait time has expired at step 328 similar
to steps 312 and 320 described above. If the wait time has
30   not expired at step 328, the HM/PSM 34 returns to step 322
while, if the wait time has expired, the HM/PSM 34 proceeds

to disconnect the current connection with the MT as will be
described herein below.

If, at step 324, a positive response is received,
the HM/PSM 34 sends a connection request to the CMAN 36 at
5   step 330 in order to update the connection table within the
CMAN 36 and subsequently monitors for a connection response
from the CMAN 36 at step 332. Once the connection response
is received at step 332, the HM/PSM 34 sends a connected mode
request to the MT and its RAP at step 333 if the MT was
10   previously instructed to be placed into the dormant mode.
Next, the HM/PSM 34 inserts the connection details within a
local table at step 334 and sends a handoff message to the MT
via the RLA/RRM 32 and its current RAP at step 336, this
handoff message instructing the MT to update its pilot sets
15   and listen to the new channels within the new sector. The
HM/PSM 34 then monitors for a handoff complete message at
step 338.

Once the HM/PSM 34 has received the handoff
complete message at step 338 or the wait time expires at any
20   one of steps 312, 320 or 328, the HM/PSM 34 next proceeds to
disconnect the old connection utilized by the MT. To do
this, the HM/PSM 34 sends an old connection disconnect
request to the CMAN 36, the CMAN 36 then coordinating the de-
allocation of the SDU, DTC and DSC of the previous
25   connection. Next, the HM/PSM 34 monitors for an old
connection disconnect response from the CMAN 36 at step 342.
Once this old connection disconnect response is received, the
HM/PSM 34 removes the old connection details from its local
table at step 344 and returns to step 300 in which it
30   monitors for PSM messages that might indicate that a hard
handoff needs to be performed for a particular MT.

The above description of a procedure performed
within the HM/PSM 34 is only one particular implementation of
the present invention. It should be understood that there
are numerous possible alternative embodiments of the present

5   invention. For instance, the HM/PSM 34 could have less
direct control over the DSC, DTC and SDU allocation or could
have more control over the de-allocation of the network
resources of the old connection. Further, the HM/PSM 34
could only send dormant mode requests for particular network

10   resource allocation failures rather than for any such failure
as shown in FIGURE 5. Yet further, it should be recognized
that the procedure of FIGURE 5 is specific to the HM/PSM 34
being used for a single MT, though in reality the HM/PSM 34
could be performing this procedure (at different steps within

15   the procedure) for a plurality of MTs within a plurality of
different sectors controlled by a plurality of different
RAPs. Even further, it should be recognized that the
connected mode request could be sent at alternative points
within this procedure. For instance, the connected mode

20   request could be performed after any positive allocation
response (such as after steps 308, 316 and 324) if a dormant
mode request was sent previously. Also, in alternative
embodiments, additional dormant mode requests and/or
connected mode requests could be sent by the HM/PSM 34 with

25   the requests being ignored if the MT is already within the
requested mode.

As well, although the present invention has been
described above with particular steps indicating times in
which it is determined whether the wait time has expired,

30   this should not limit the present invention. In some
embodiments of the present invention, the wait time is

consistently being determined, a wait time flag being triggered if the wait time expires. In this case, after the wait time flag is triggered, the procedure proceeds to step 340 and the disconnecting of the old connection.

5   Although the description of the present invention above is specific to the wireless network architecture of FIGURE 2, it should be understood that this is not meant to limit the scope of the present invention. More or less components could work together to perform a hard handoff

10   procedure of a MT. Further, the decision to send a dormant mode request and subsequently a connected mode request to a MT could be made in another component besides the HM/PSM as described above. For instance, the decision to send a dormant mode request to a MT could be generated within the

15   RLA/RRM or another device that is aware of network resource allocation failures.

           The present invention has been described herein above as being implemented within a hard handoff procedure. Alternative embodiments of the present invention are

20   implemented within other situations in which a lack of network resources makes a connection for a MT temporarily disconnected. In such a situation, the forcing of the MT into a dormant mode can preserve the packet data session while the wireless network attempts to reconnect the

25   connection.

           One possible implementation of the present invention in which such a situation occurs is with respect to a first MT being handed off by a first sector while there is not sufficient network resources to accommodate it within a

30   new sector. In this case, a second MT within the sector that is within a packet data session could be put within a dormant

mode while the first MT utilizes the network resources of the
second MT. Subsequently, as network resources become
available, the connection for the second MT could be re-
established. In this implementation, a priority system could
5   dictate which MT is put into the dormant mode to accommodate
the first MT. If the first MT is of a relatively high
priority level, a MT with a relatively low priority could be
put into the dormant mode to allow for sufficient resources
to be provided to the first MT.

10   In another possible implementation of the present
invention in which the placement of a MT within a dormant
mode could be performed is in case of other situations of a
cell overload condition. Similar to described above, in the
case that a network detects a cell overload condition, the
15   network can place one or more MT within the dormant mode. In
this situation, the selection of MTs to be placed within the
dormant mode is made based upon a priority system similar to
that described above.

          Within any of the embodiments of the present
20   invention, a controlling element within a network, preferably
a RAP, can maintain an internal queue of MTs that have been
forced into the dormant mode or have been forced to remain in
dormant mode after they requested transition into an
connected mode. In the case that a queue system is utilized,
25   the network can control the packet data load within a
particular sector or cell by waking up (i.e. forcing into
connected mode) MTs according to a predetermined queuing
discipline. This predetermined queuing discipline could be
based upon a number of different techniques such as a pure
30   priority system, a round robin system or a weighted fair
share system. In some embodiments, a maximum dormant time

that a MT can be forced to remain in the dormant mode between
"awakenings" can be determined based upon a minimum level of
QoS required by a particular application. In these
embodiments, this maximum dormant time is the time in which

5   the application can be maintained with minimum functionality
before application errors occur. Preferably, any queue
system that is utilized would attempt to ensure no MT
exceeded its corresponding maximum dormant time.

The use of the present invention in general can

10   preferably allow for an increased flexibility for the
wireless network, increased cell breathing without effecting
the quality of service of the network as a whole and
increased survivability for individual subscribers.

Throughout the above description, the present

15   invention is assumed to be used for data traffic within
packet data session. It should be recognized that the
present invention could further be used for packet-based
voice traffic such as Voice over Internet Protocol (VoIP)
traffic. In this case, a warning is preferably given the

20   users of the VoIP terminals that their connection will be
placed on hold when one of the terminals receives the dormant
mode request.

Persons skilled in the art will appreciate that
there are yet more alternative implementations and

25   modifications possible for implementing the present
invention, and that the above implementations are only
illustrations of certain embodiments of the invention. The
scope of the invention, therefore, is only to be limited by
the claims appended hereto.